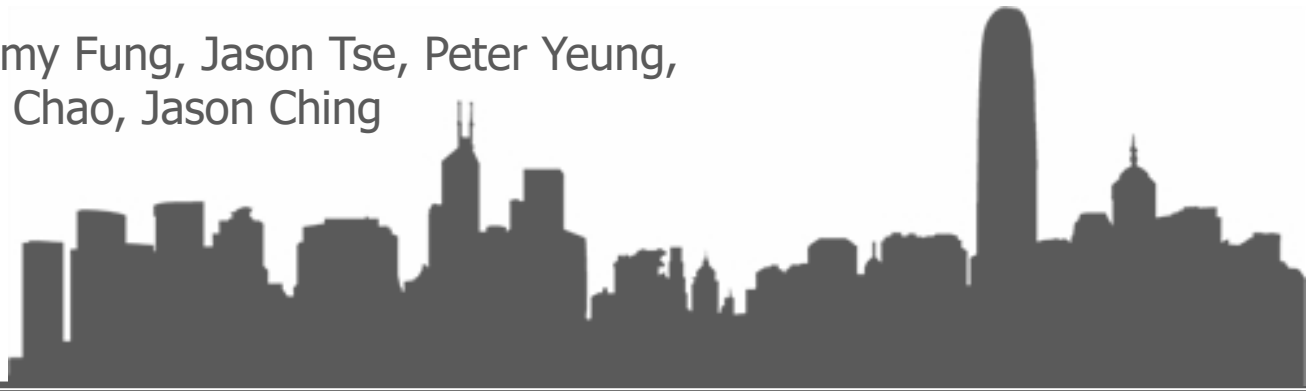
Evaluation of urban-WRF performance in Hong Kong

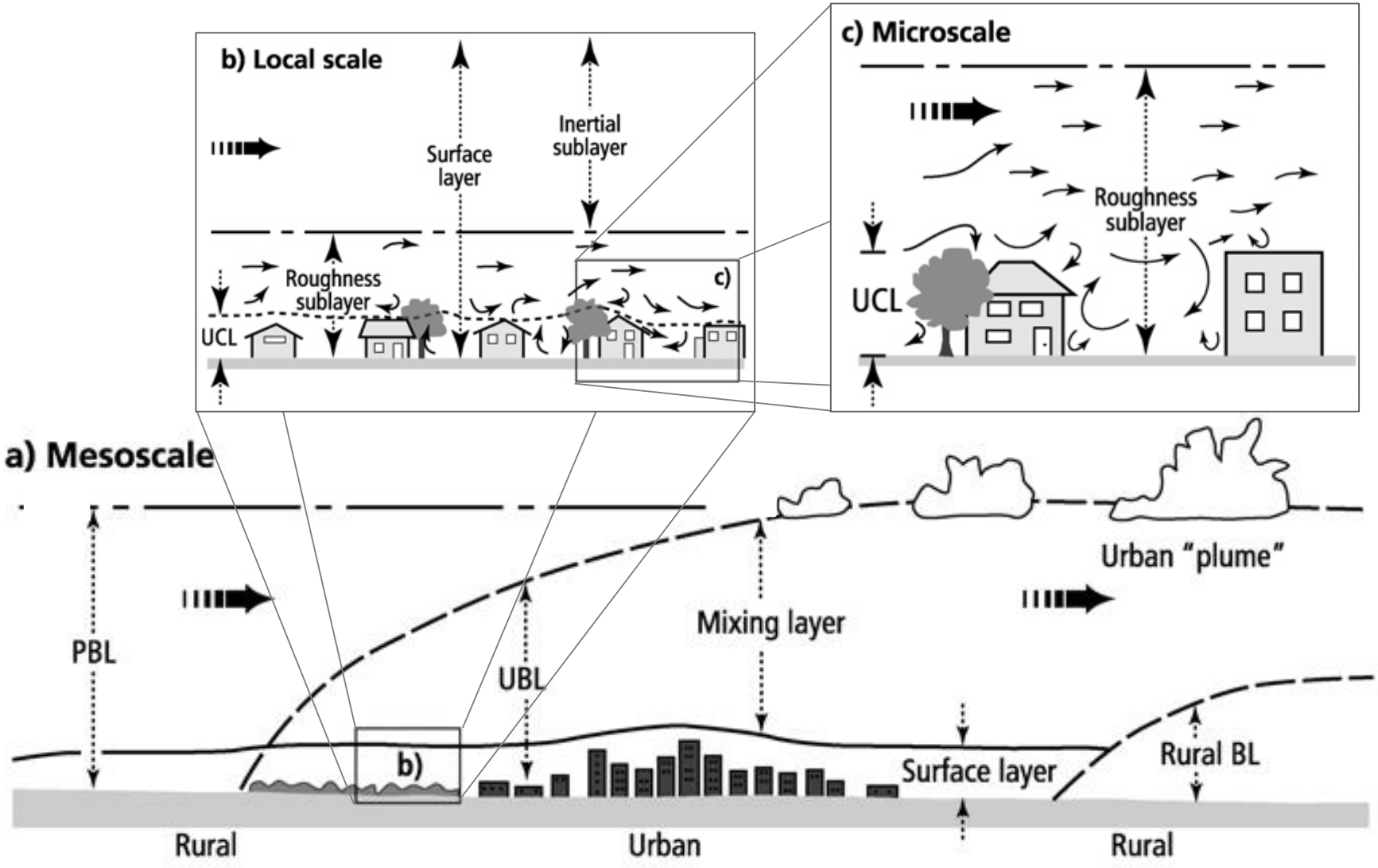
With WUDAPT input dataset & the guidance for implementation

Michael Wong, Jimmy Fung, Jason Tse, Peter Yeung,
Ren Chao, Jason Ching

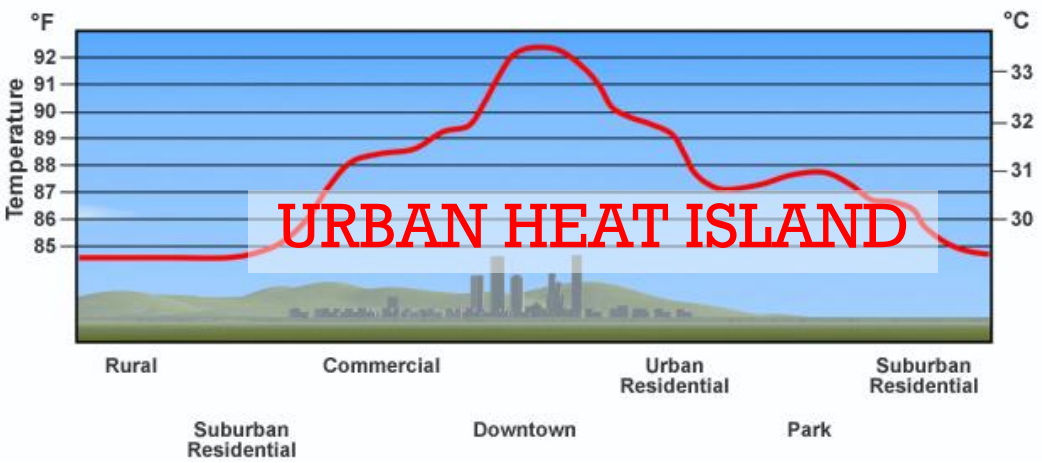


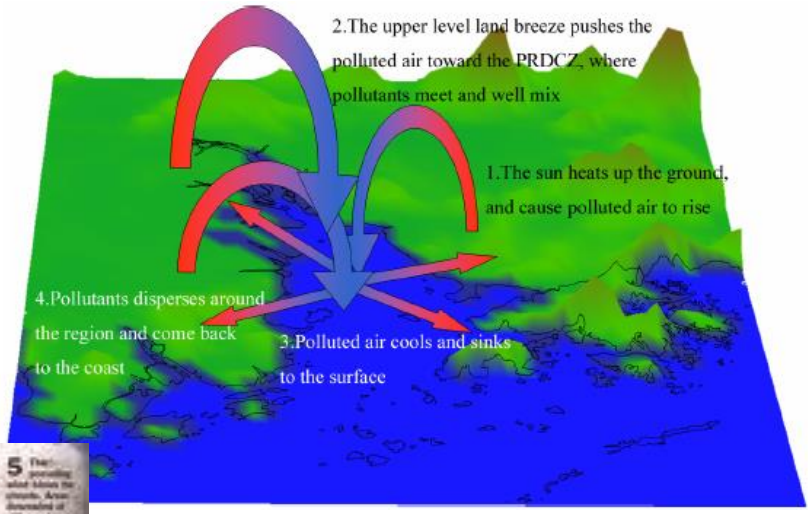
香港科技大學
THE HONG KONG
UNIVERSITY OF SCIENCE
AND TECHNOLOGY

Urban Meteorology and
Climate Conference
26. May 2017, Hong Kong


b) Local scale
Surface layer
Inertial sublayer
Roughness sublayer
UCL
c)
c) Microscale
Roughness sublayer
UCL
a) Mesoscale
Urban "plume"
Mixing layer
PBL
UBL
b)
Surface layer
Rural BL
Rural
Urban
Rural

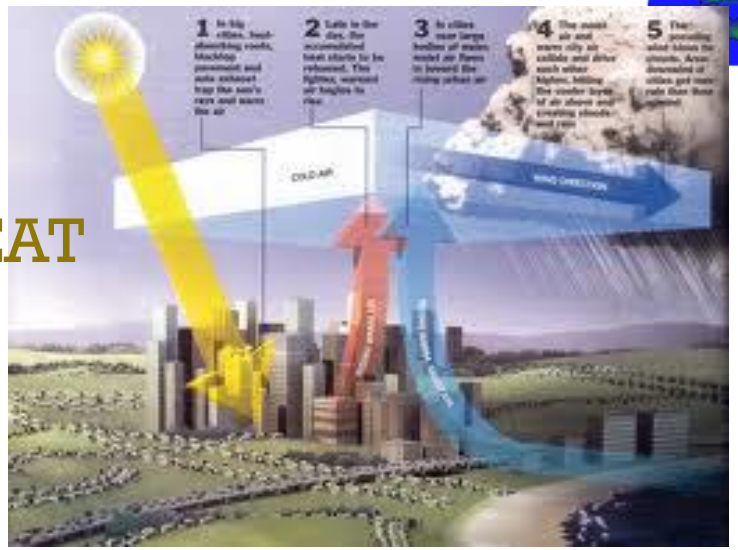
COMMON METEOROLOGICAL PHENOMENA





LAND-SEA-BREEZE CIRCULATION

URBAN HEAT PLUME



URBAN DEVELOPMENT

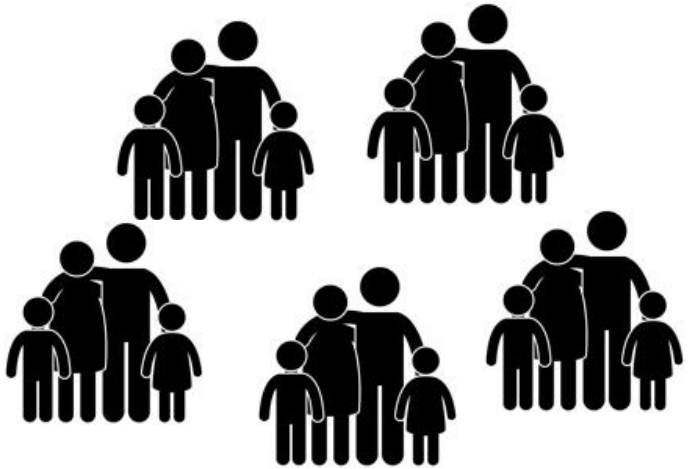
Las Vegas (1984-2016)

Urban Development

Hong Kong

IMPACT

URBAN CLIMATE &
URBAN BOUNDARY LAYER



Overview of Urban meteorology research

Measurement/ Observation

Theories/ Modeling

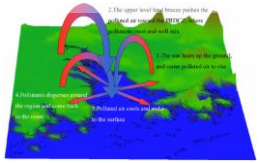
Urban Meteorology

Air Quality Modeling

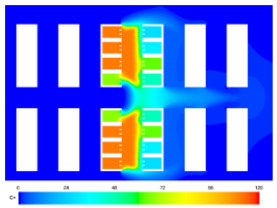
Scenario studies/ Projection

Peter Yeung et. al

Land Sea Breeze Circulation



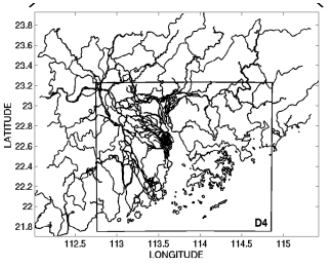
You Cheng et. al

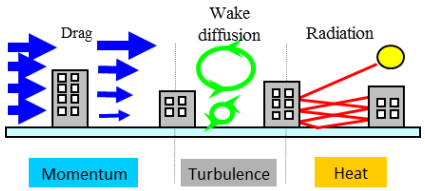


CFD Modeling

An Karl et.al

Parameterization

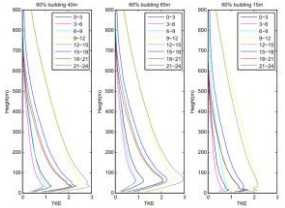




What, why, how?
→ Dynamics

TKE-Budget

Michael Wong et. al



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TKE = Turbulence Kinetic Energy

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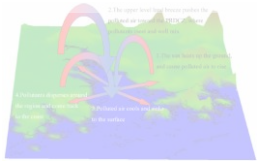

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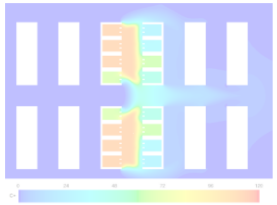

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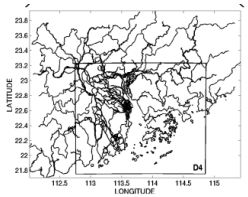

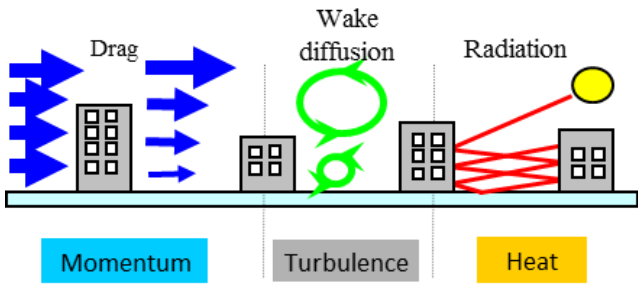

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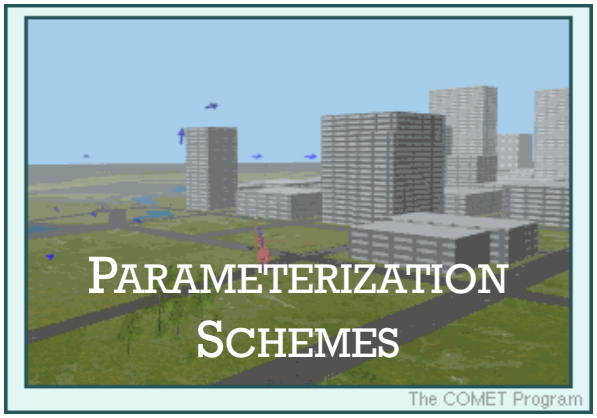
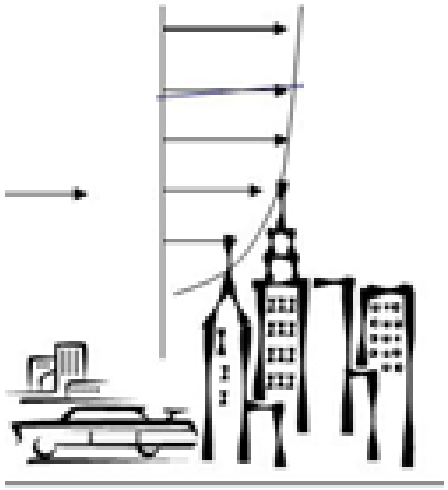
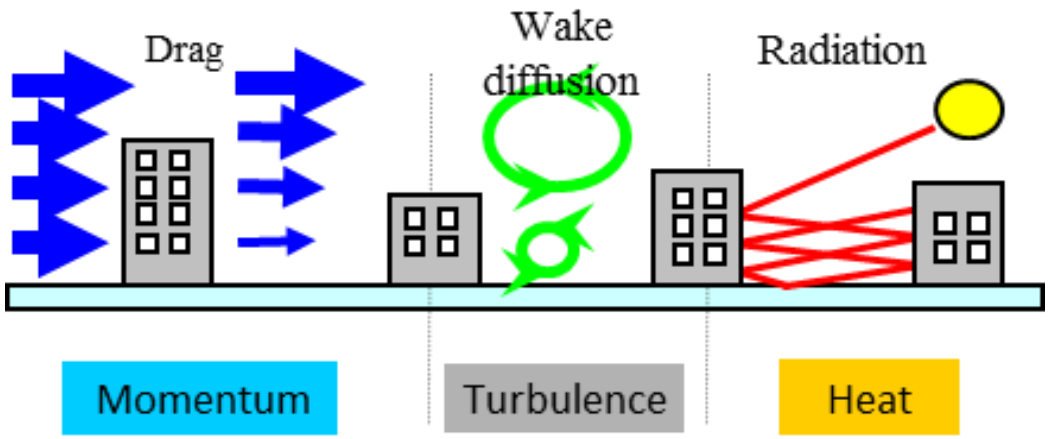


URBAN CANOPY MODEL



BULK SCHEME
(based on similarity theory)

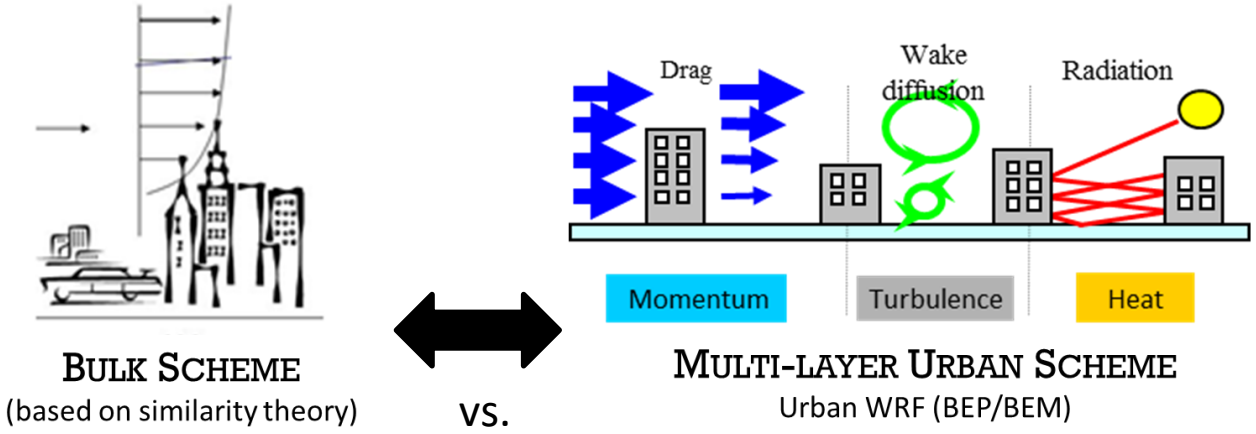


MULTI-LAYER URBAN SCHEME
Urban WRF (BEP/BEM)

Martlili et. al 2002

Research Questions to be answered

- Question 1: How well performs the model over HK (urban WRF) ?



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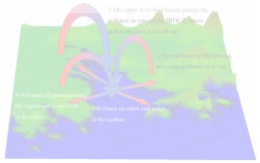
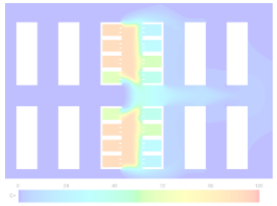


You Cheng et. al



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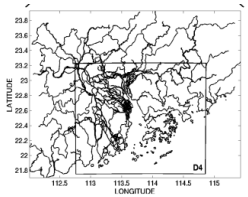

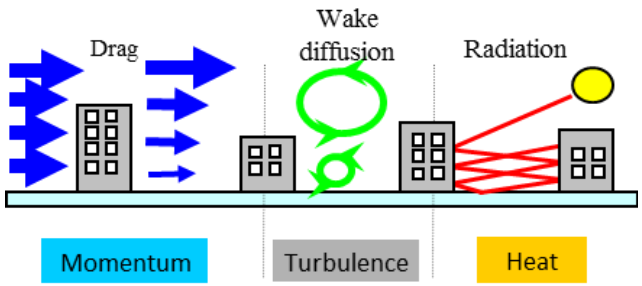

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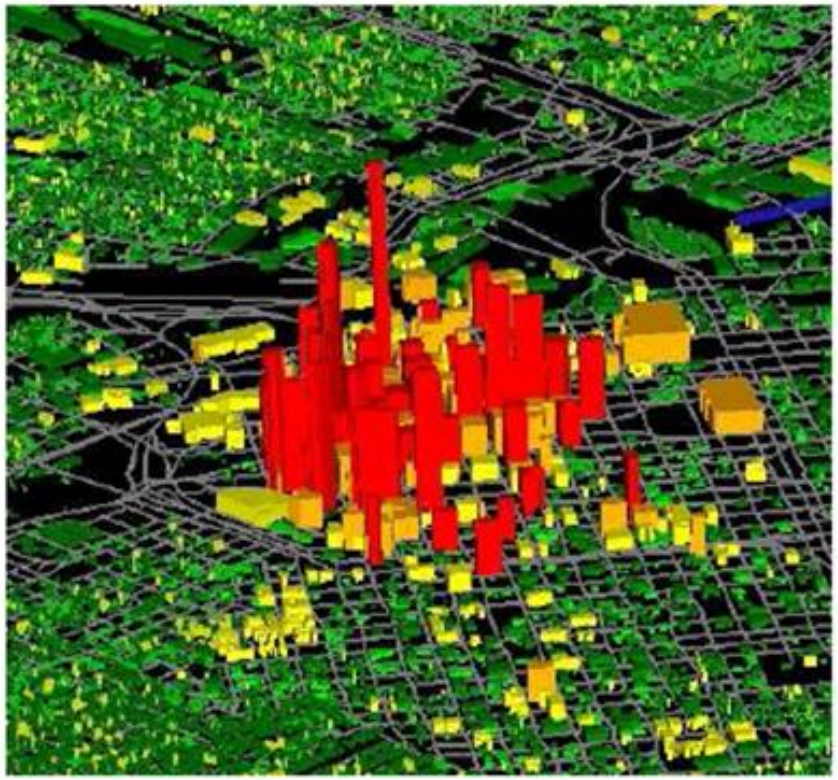
Derivation of Urban Canopy Parameters

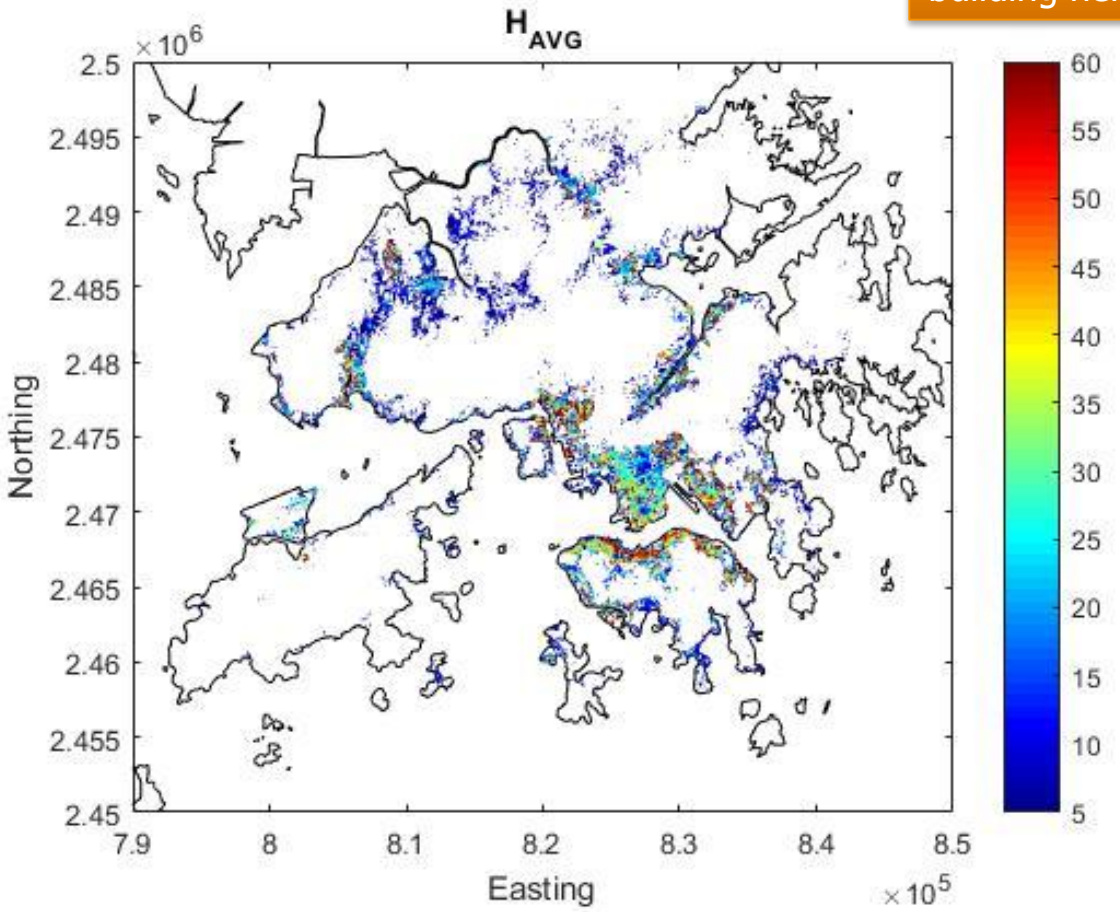


- Area-weighted Average building height
- Plan area ratio
- Building surface-to-plan area ratio
- Building height distribution

→ Real Building Data (NUDAPT)

HONG KONG - Example

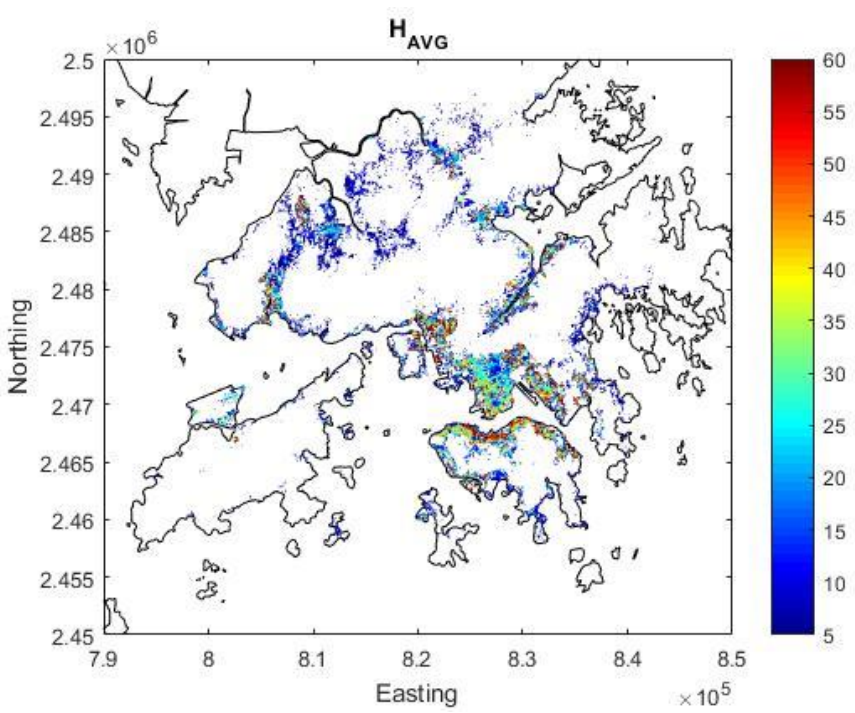
Area-weighted Average building height (H_{AVG})

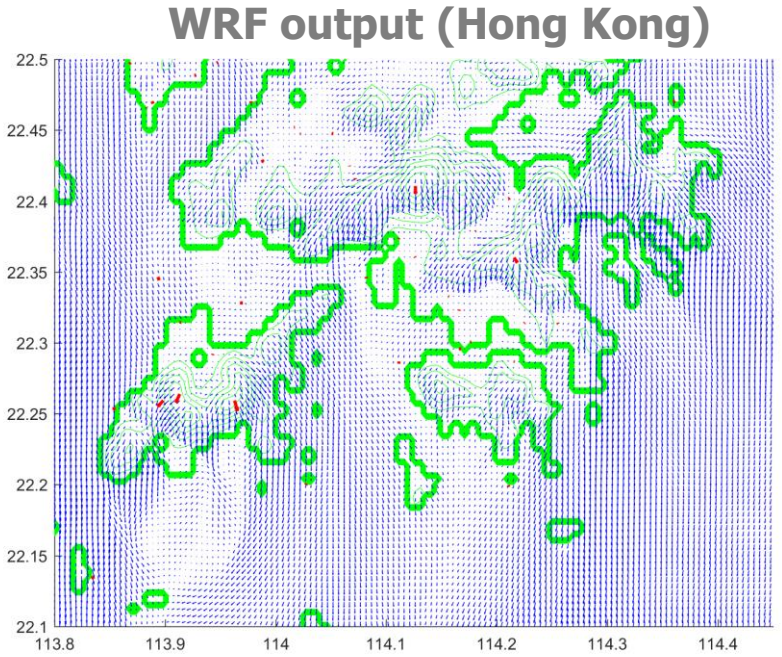


→ Real Building Data (NUDAPT)

Question 1:

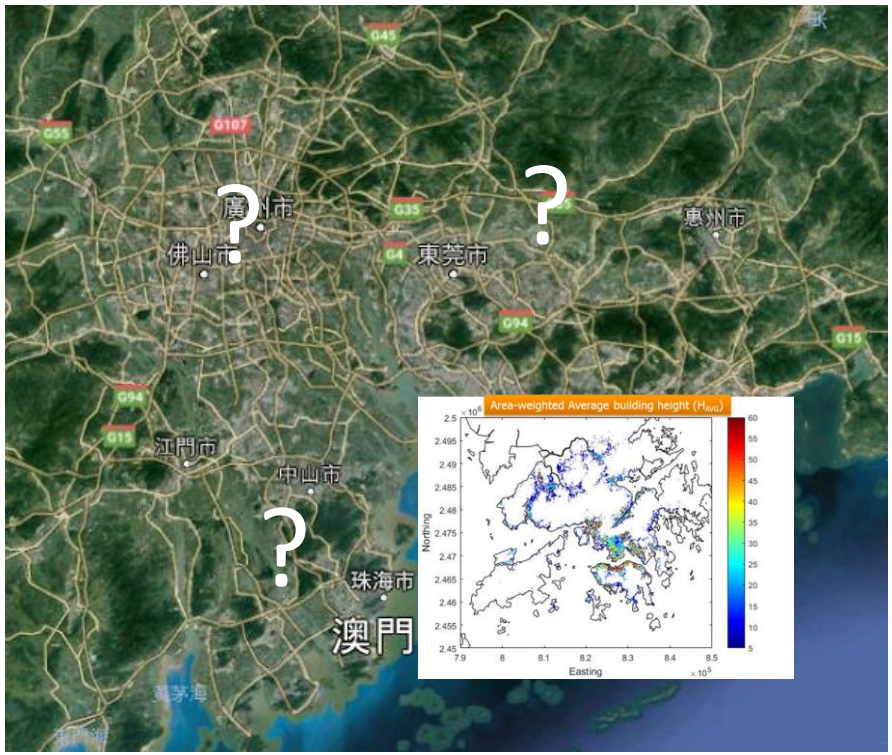
How well performs the model over HK (urban WRF)

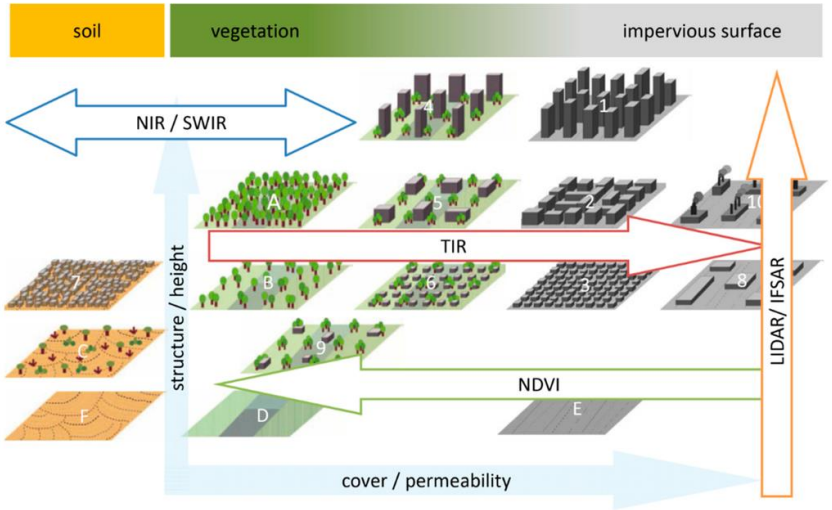




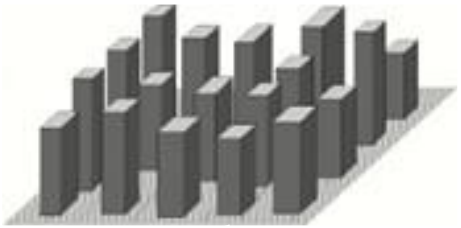
→ Real Case #1

SATELLITE ESTIMATION OF LOCAL CLIMATE ZONES (WUDAPT)





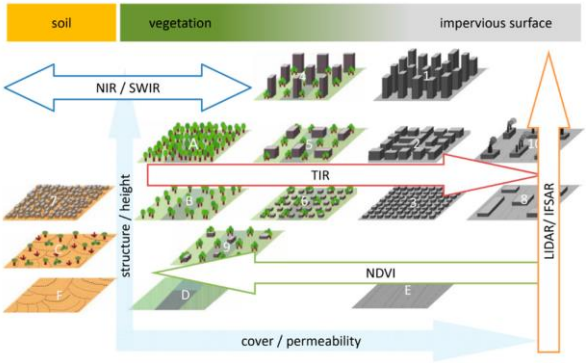
SATELLITE ESTIMATION (WUDAPT)



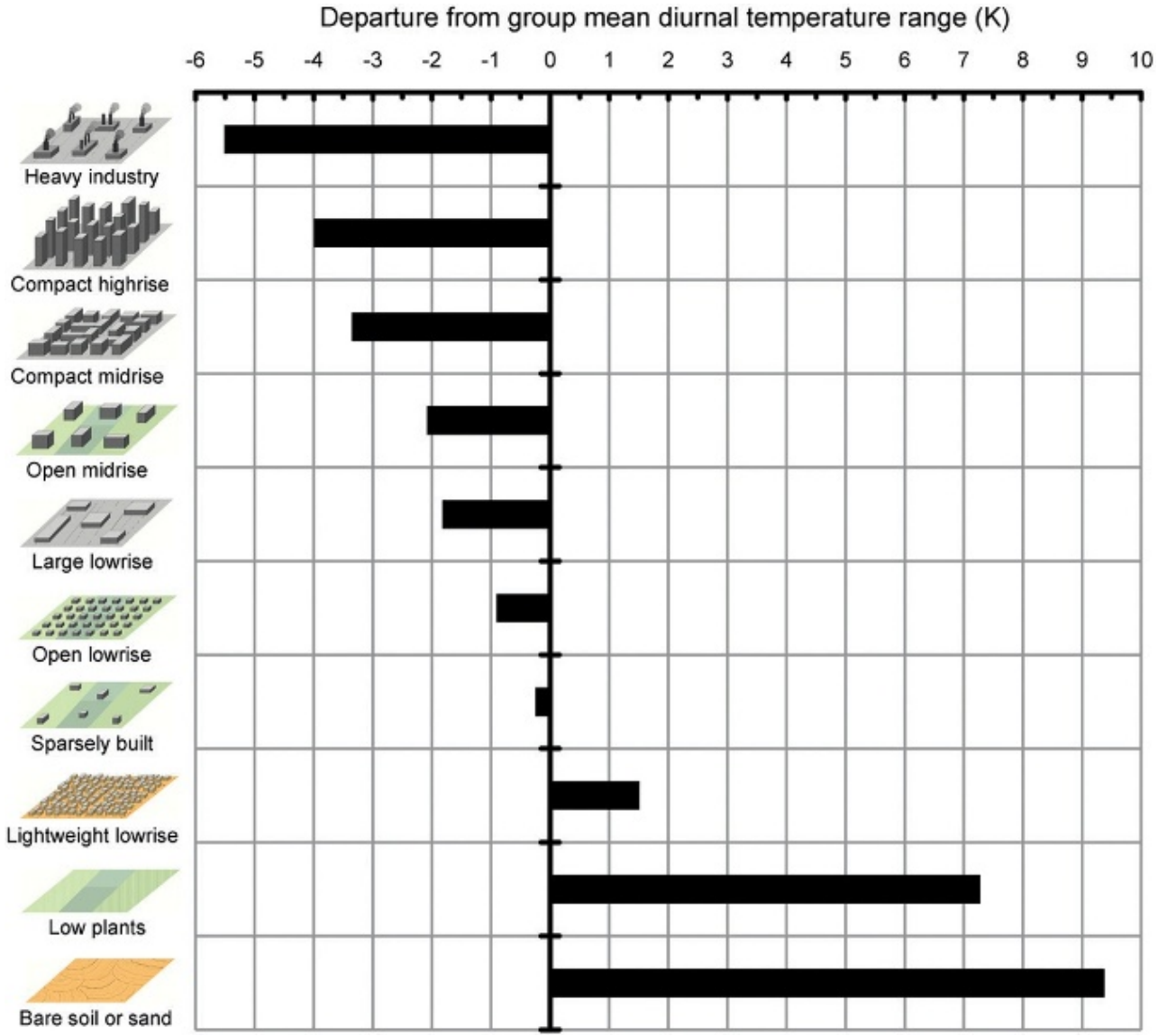
Training zone

e.g. LOCAL CLIMATE ZONE 1:
Compact high-rise

identify areas with similar spectrum properties

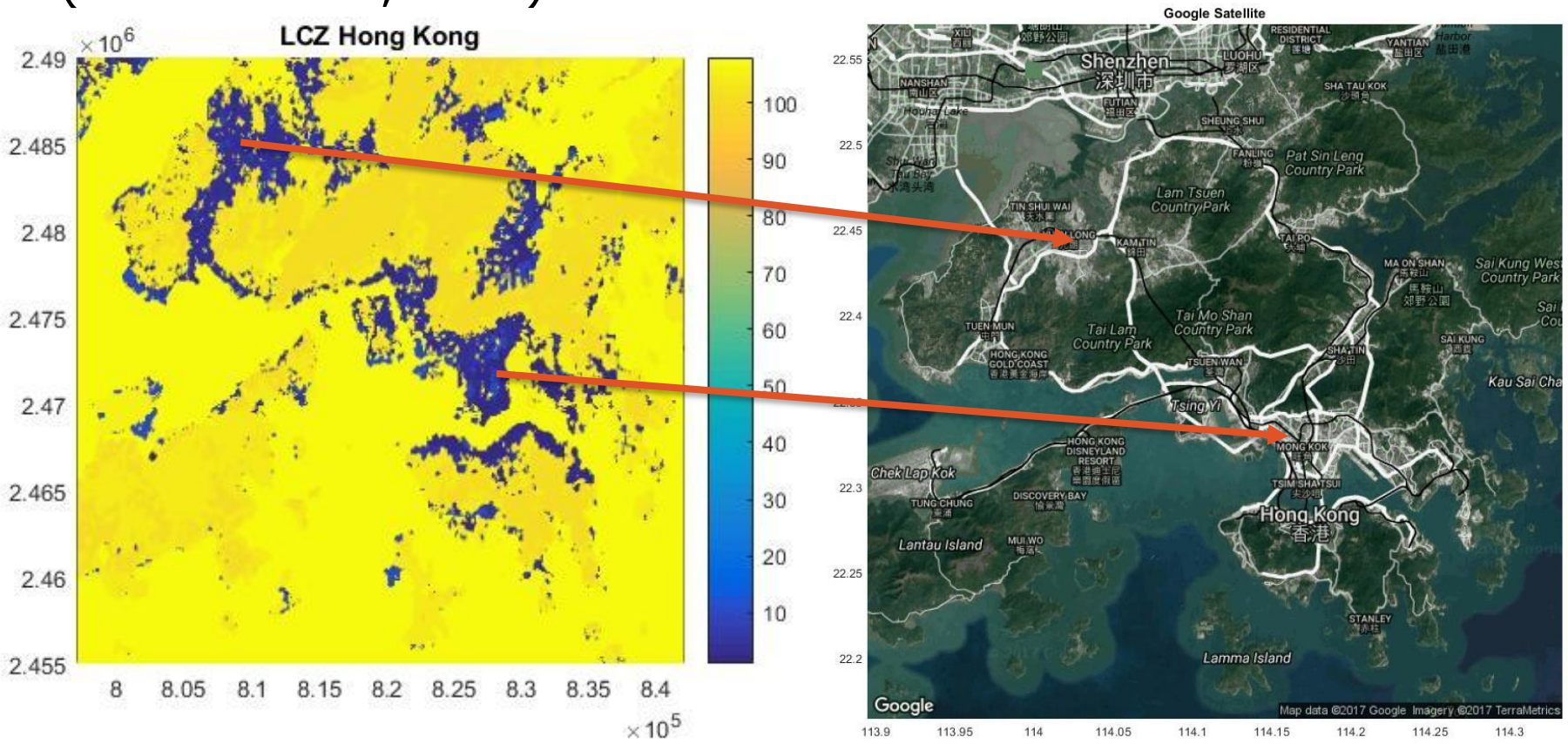


Local Climate Zone (WUDAPT)



Overview of Local Climate Zones in Hong Kong

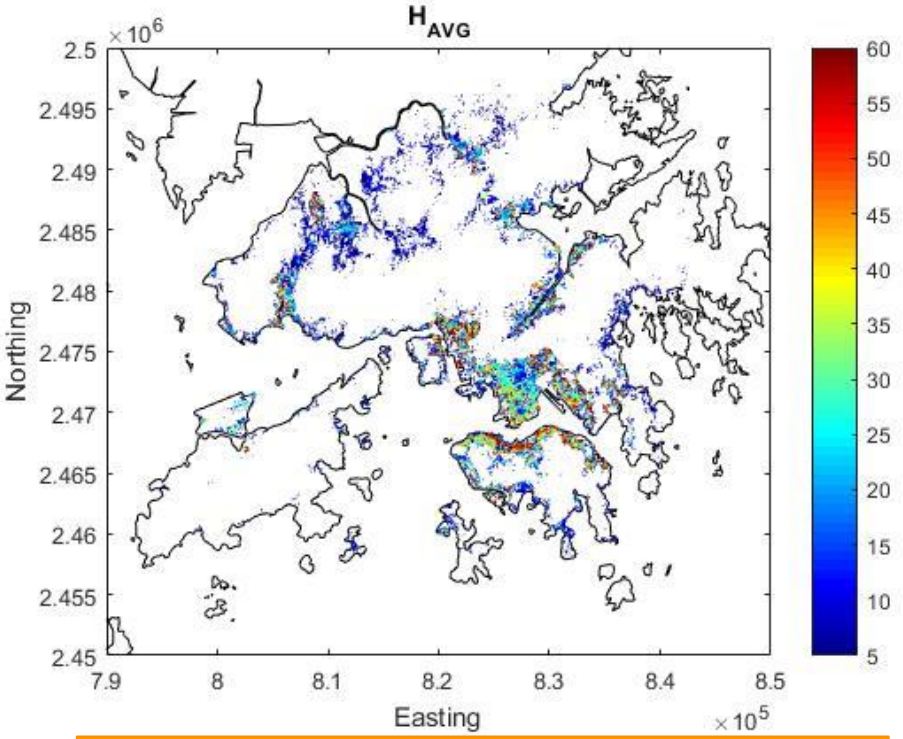
(Prof. Ren Chao, CUHK)



→ urban area in Hong Kong well identified

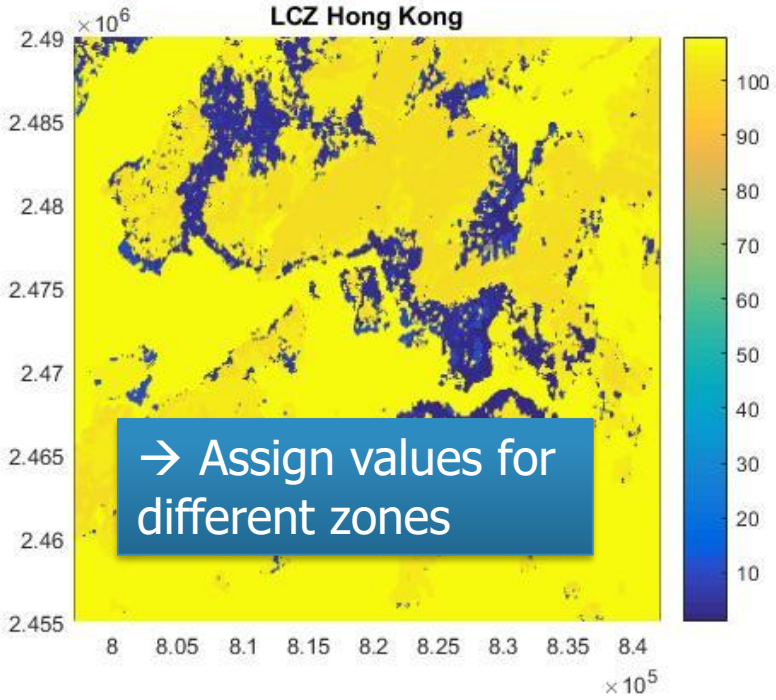
NUDAPT vs. WUDAPT

Real Building Data (NUDAPT)



Area-weighted Average building height (H_{AVG})

Satellite Estimation(WUDAPT)



→ Assign values for different zones

Research Questions to be answered

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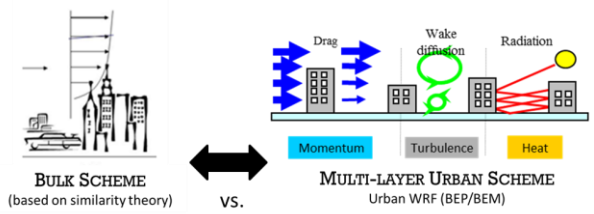
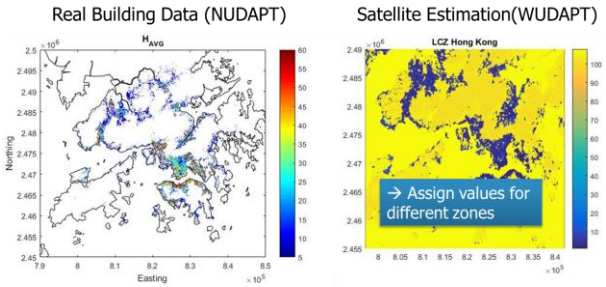


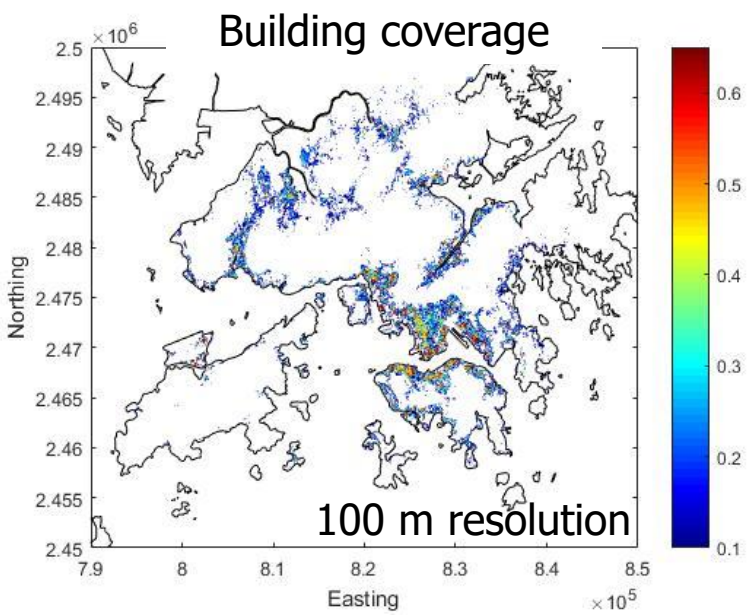
- Question 2a: Possibilities of deriving Urban canopy parameters from WUDAPT + corresponding errors?
- Question 2b: How well can satellite estimation (WUDAPT) mimic real building data (NUDAPT)?

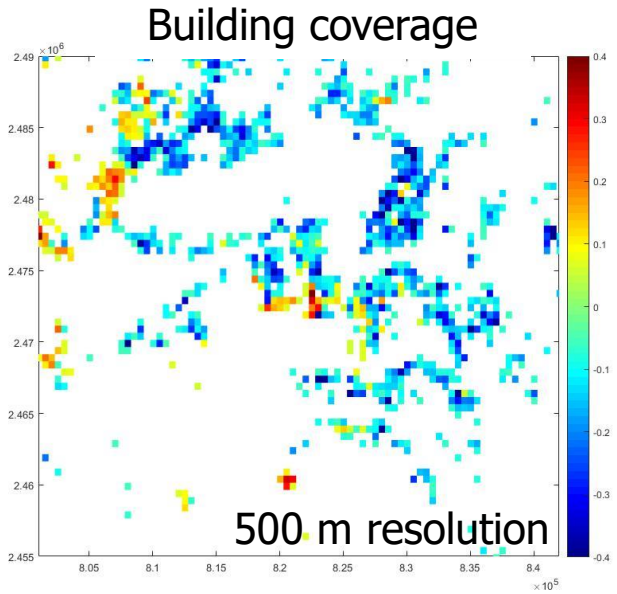


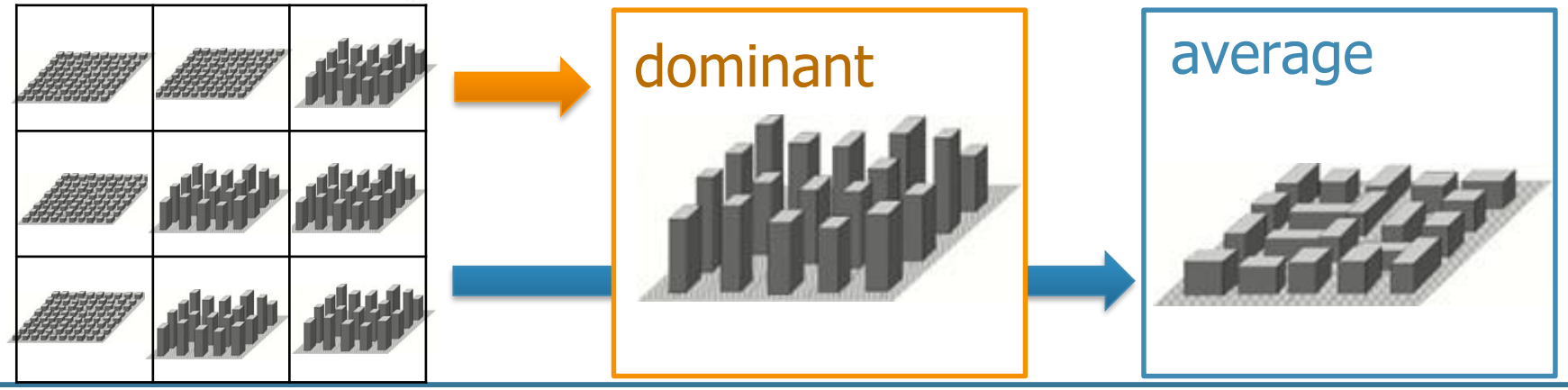
SOURCES OF UNCERTAINTY WHEN APPLYING WUDAPT IN URBAN-WRF

- Approximation of urban canopy parameters distribution
- Subsampling method (sub-grid scale feature)
- Satellite retrieved local climate zone Supervised classification method
- Lack of local information on building morphology

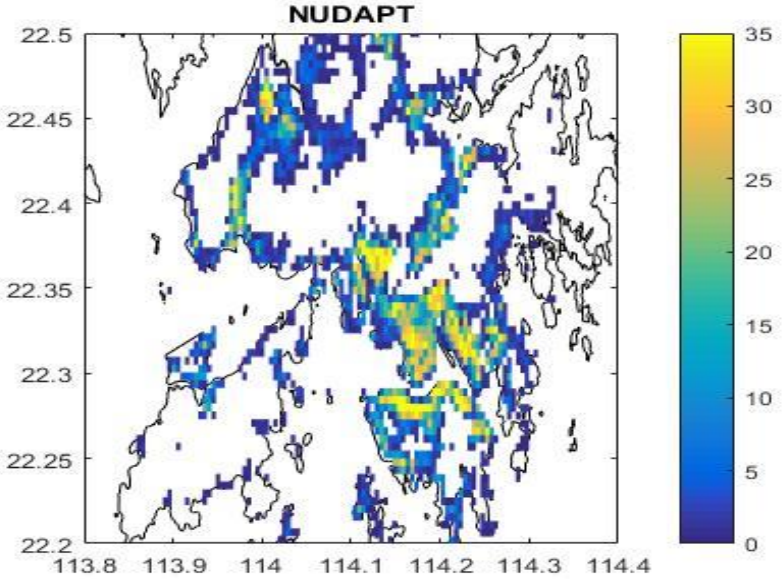
SUBSAMPLING METHOD



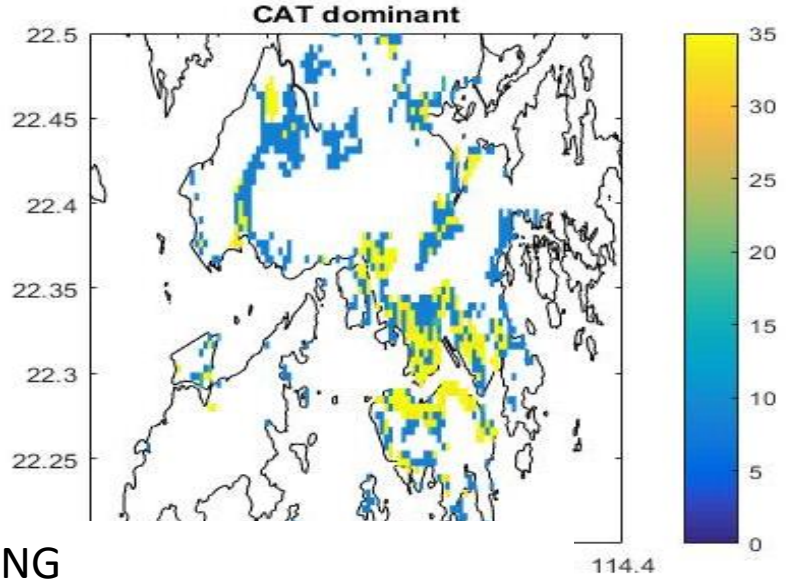




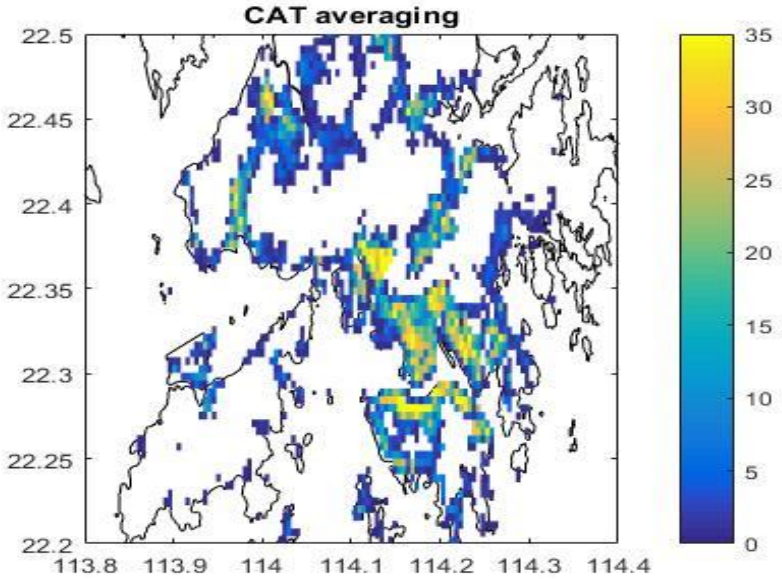
REAL BUILDING DATA



DOMINANT



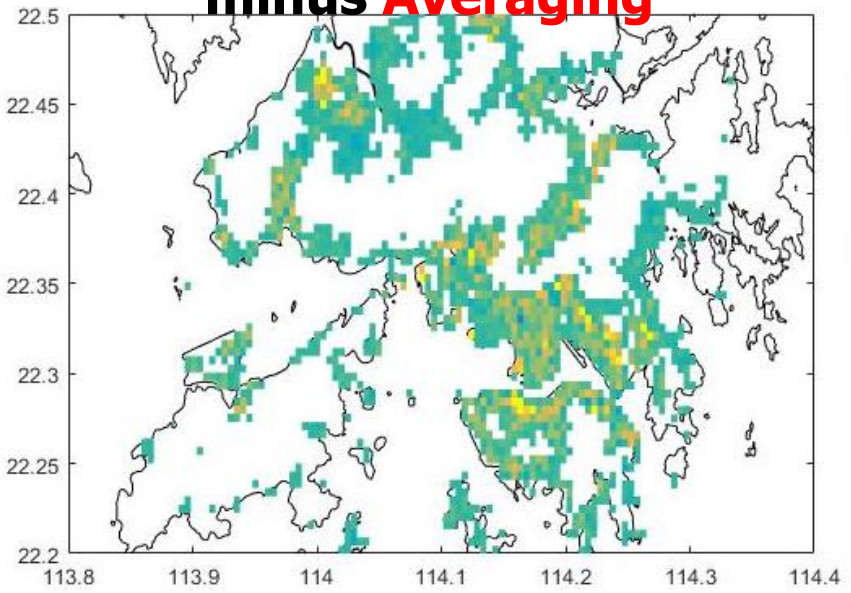
AVERAGING



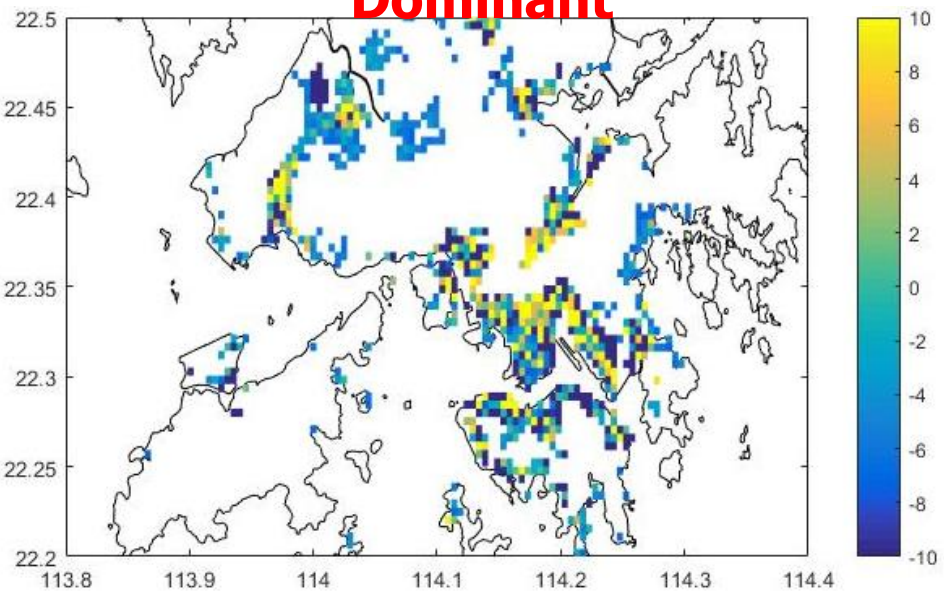
Different ways of input data treatment

Resulting in different urban morphology data sets

Real Building Data minus Averaging



Real Building Data minus Dominant



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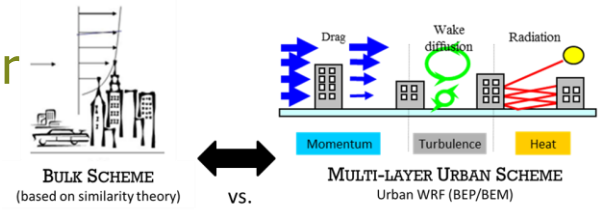

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and guidance for implementation

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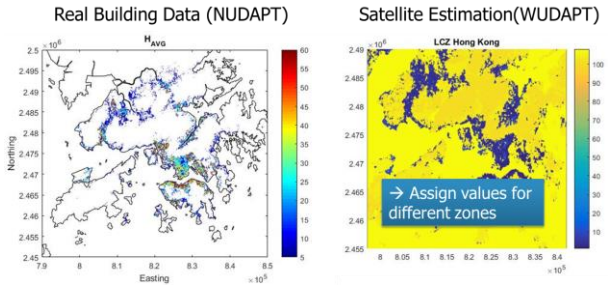
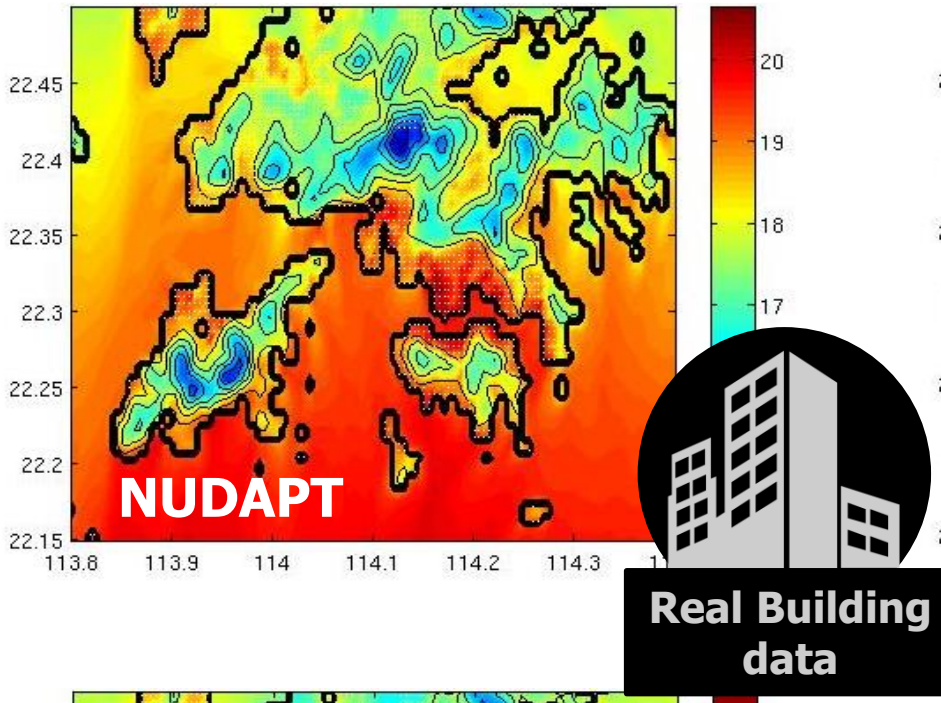
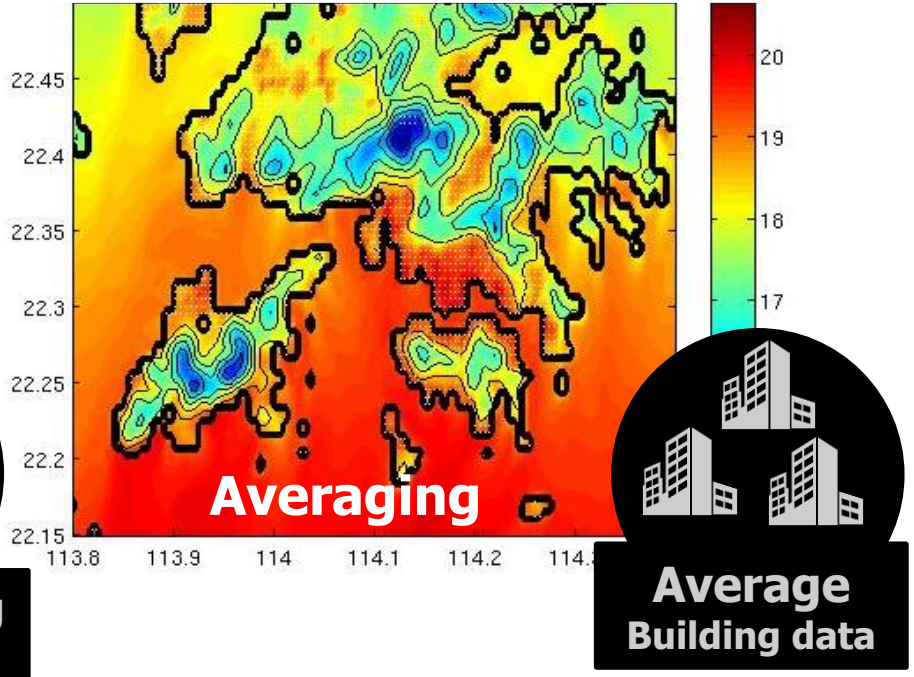
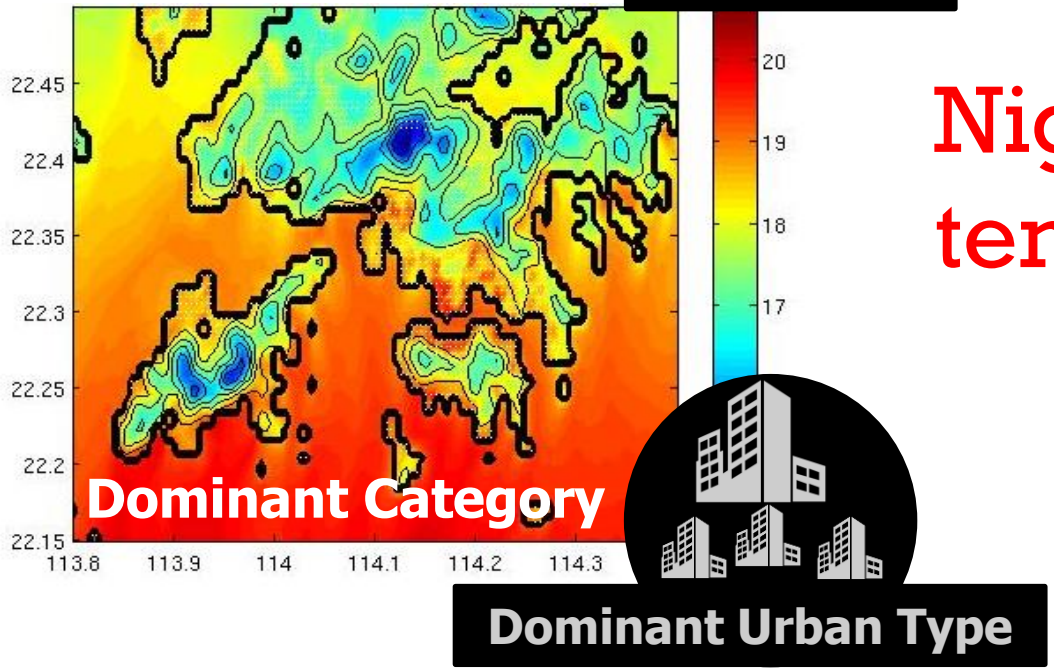






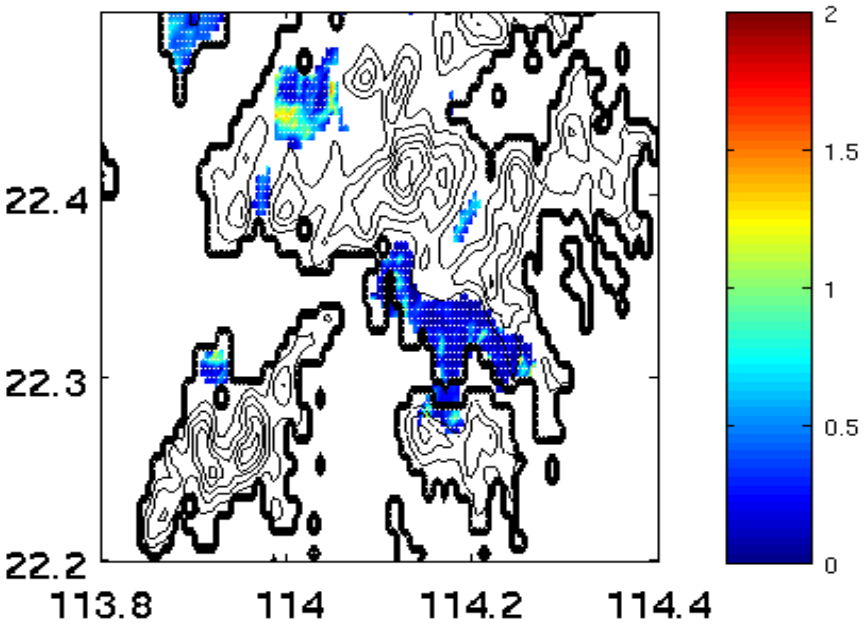


Night-time surface temperature

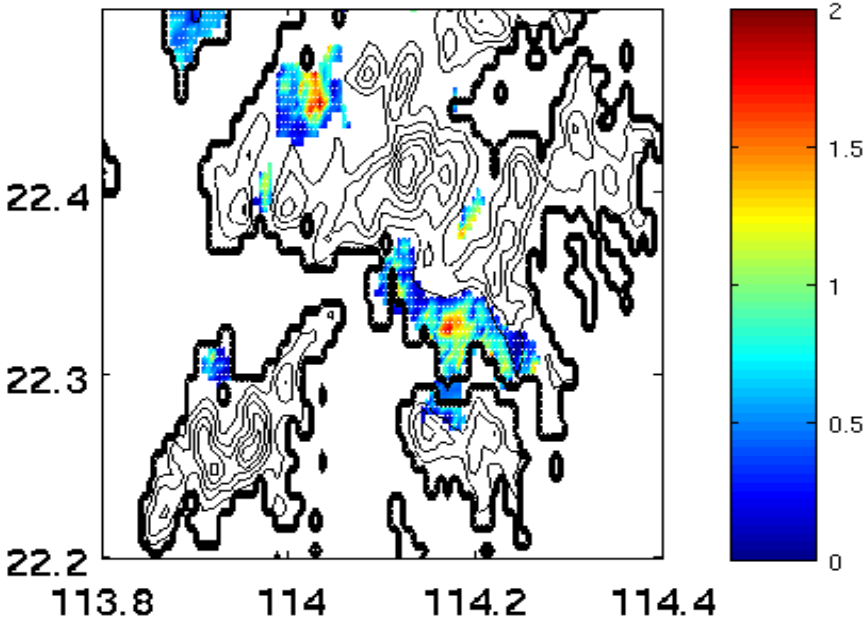
DIFFERENCE

IN NIGHT-TIME SURFACE TEMPERATURE

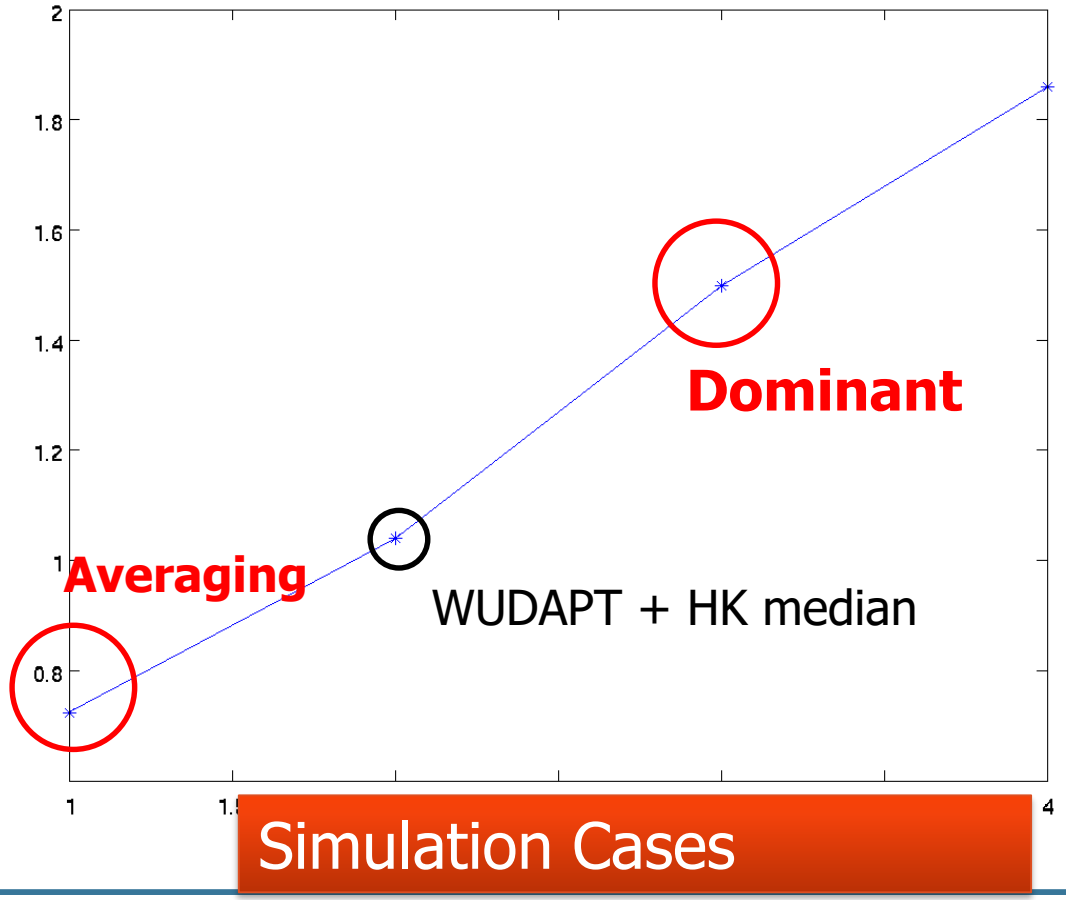
Real Building Data minus Average



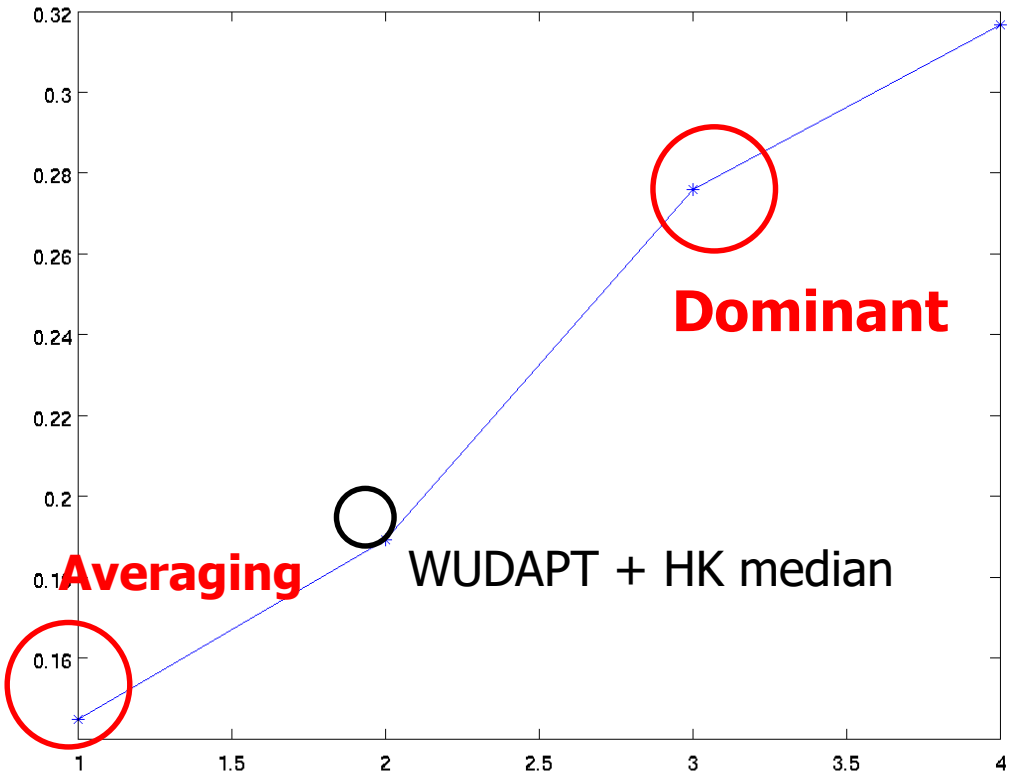
Real Building Data minus Dominant



Maxiumum Temperature difference compared to Ground Truth (NUDAPT)

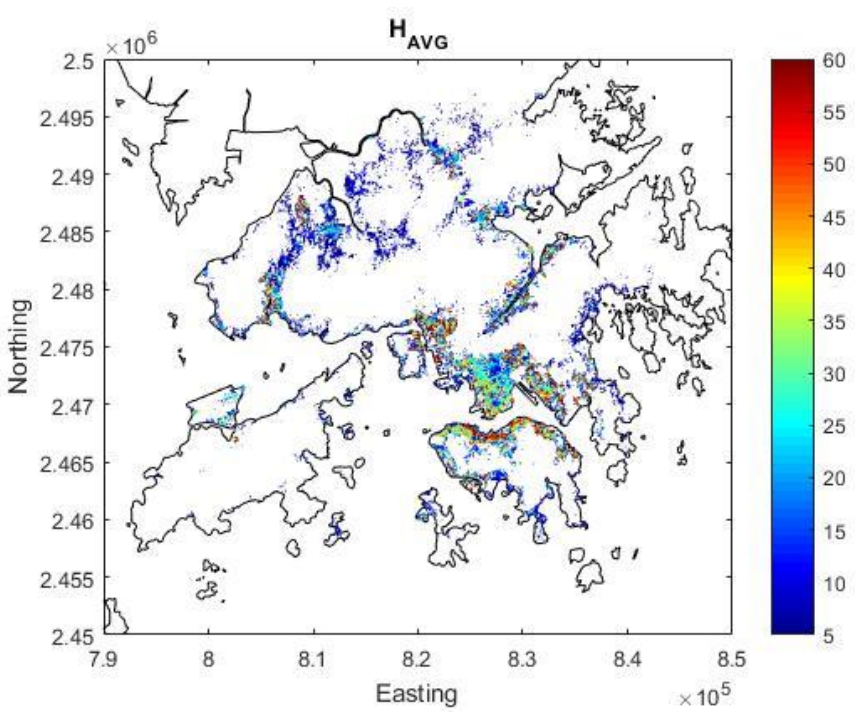


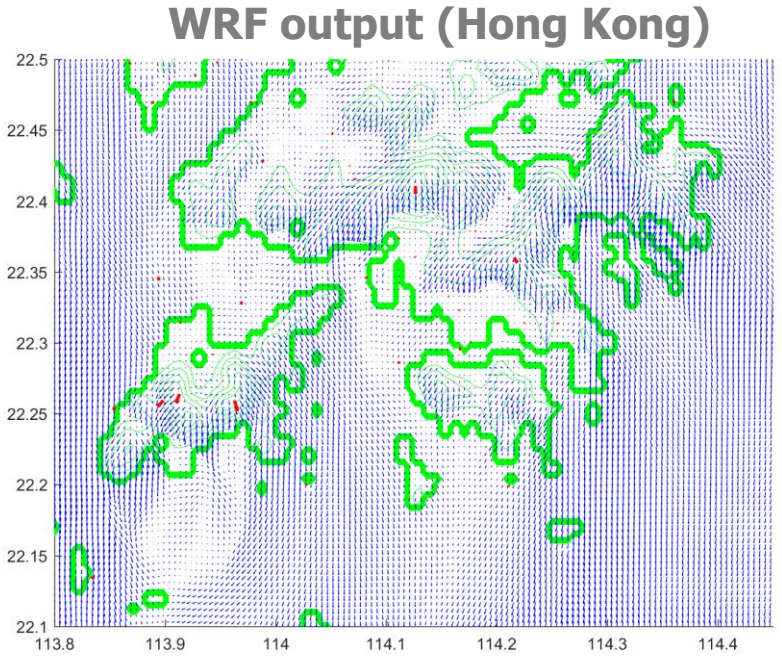
Average Temperature difference compared to Ground Truth (NUDAPT)



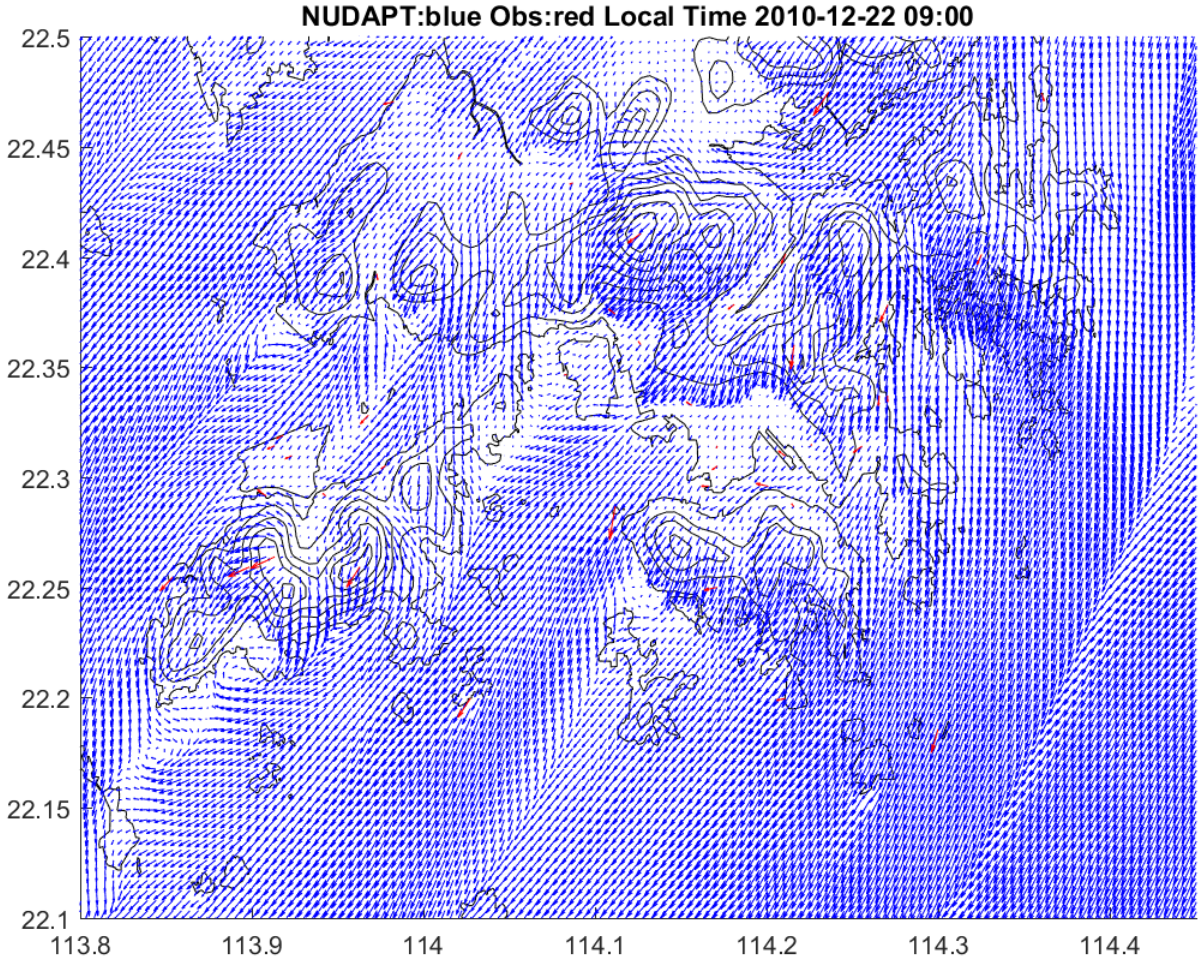
Question 1:

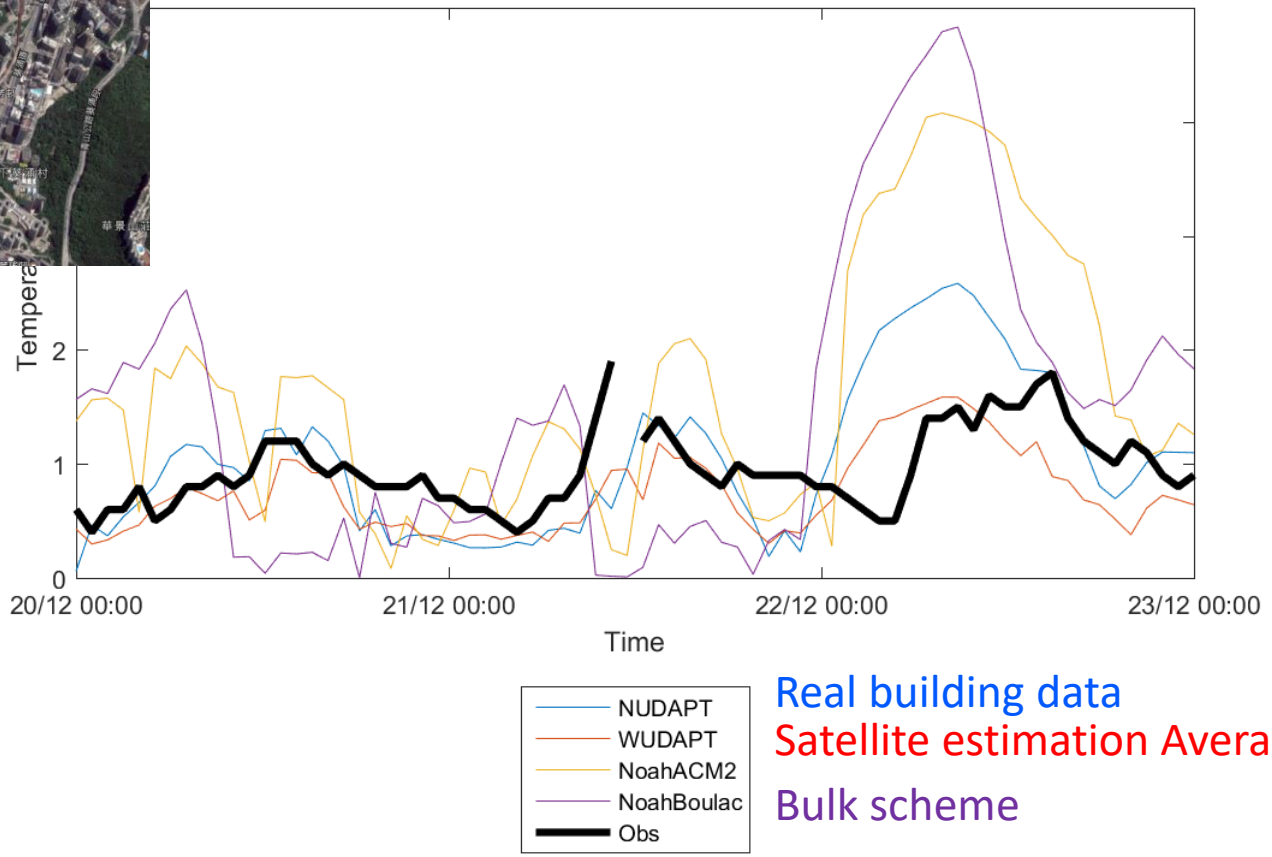
How well performs the model over HK (urban WRF)





→ Real Case #1

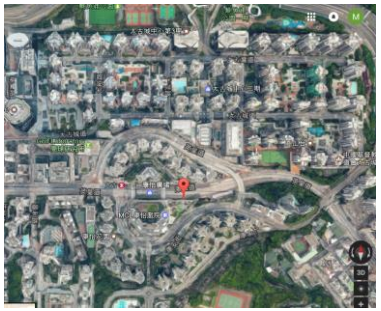

NUDAPT:blue Obs:red Local Time 2010-12-22 09:00
22.5
22.45
22.4
22.35
22.3
22.25
22.2
22.15
22.1
113.8
113.9
114
114.1
114.2
114.3
114.4

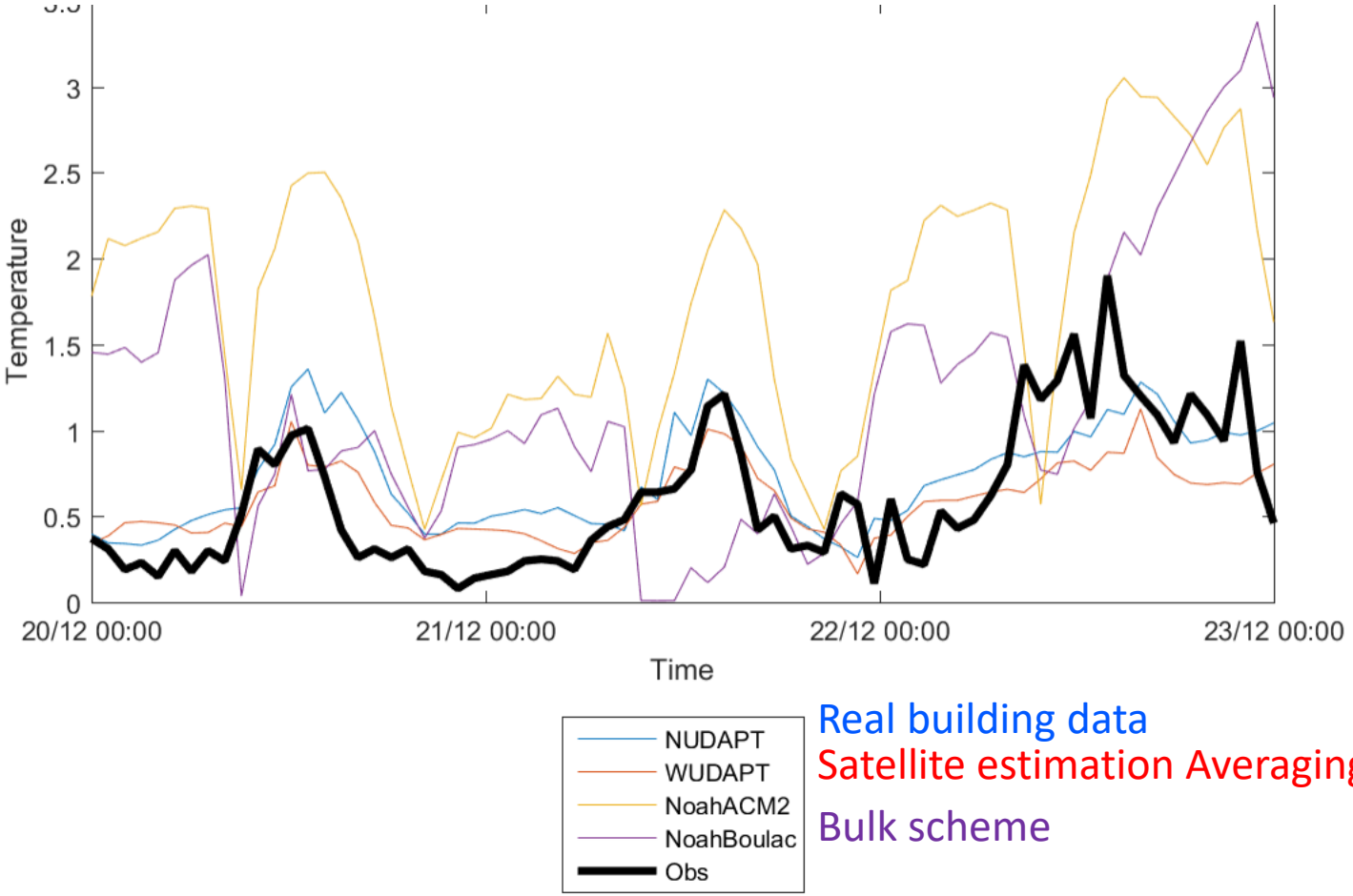


Real building data

Satellite estimation Averaging

Bulk scheme





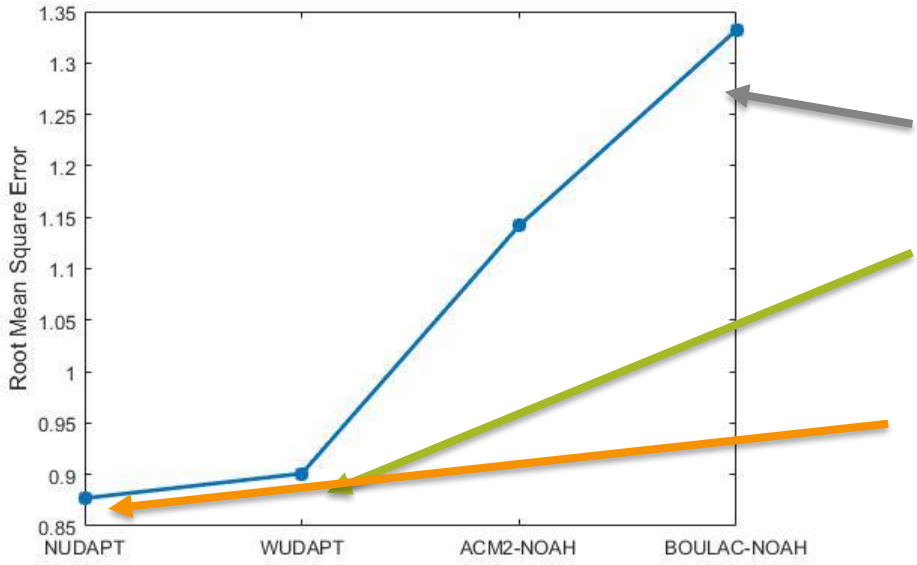
Real building data

Satellite estimation Averaging

Bulk scheme

Study Period (2010-12-19 to 2010-12-22)

- Root Mean Square Error (performance over all 'urban sites')



Real building data

Satellite estimation Averaging

Bulk scheme

Conclusion:

1. ACM2 and BOULAC show largest RMSE, ACM2 is better than BOULAC
2. NUDAPT performance is slightly better than WUDAPT, both of them are better than NOAH
3. WUDAPT could be an approximation for NUDAPT

CONCLUSION

1. framework for evaluating the 'best practice' of utilizing the WUDAPT dataset
2. Multilayer scheme REAL BUILDING DATA (NUDAPT BEP Hong Kong) performs better than Noah Bulk Scheme (wind speed)
3. SATELLITE ESTIMATION (WUDAPT) is closer to REAL BUILDING DATA (NUDAPT) in terms of performances
4. Averaging approach and local information is preferred
5. Further improvement of WUDAPT dataset required